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Benz et al.

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(54) **PACKING SCREW REMOVAL TOOL**

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F04B 19/22 (2006.01)

(52) **U.S. Cl.**
CPC ***B25B 13/481*** (2013.01); *F04B 19/22* (2013.01)

(58) **Field of Classification Search**
USPC 81/52, 488; 269/45, 95, 3, 6; 29/255, 29/263, 278
See application file for complete search history.

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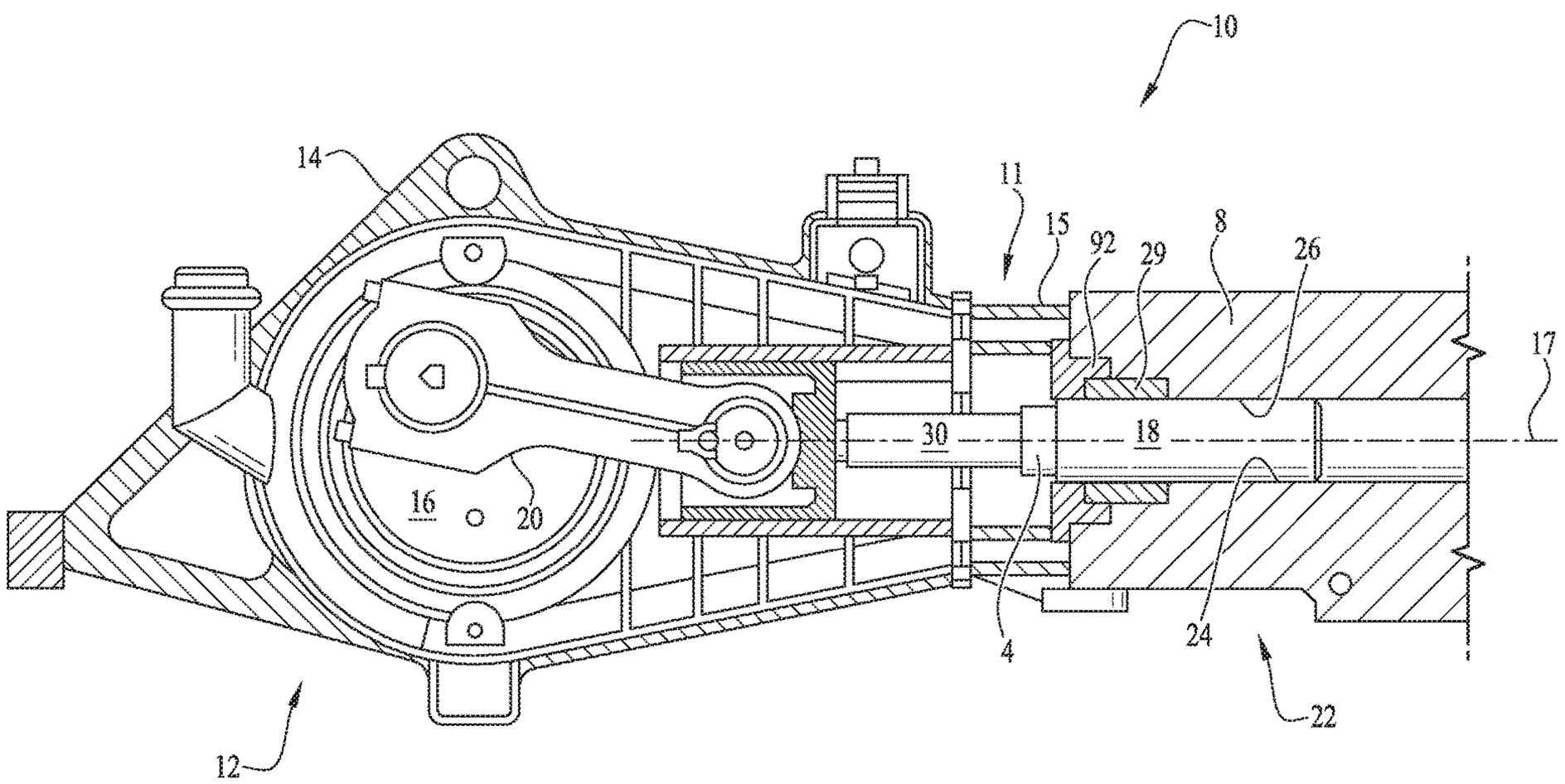
(57) **ABSTRACT**

A packing screw removal tool for removing packing from a pump fluid end comprising: a tool body; a plurality of packing screw engagement dogs distributed about an axis of rotation about the packing screw removal tool; and a torque transfer engagement post coupled to the tool body. The engagement dogs align with and are releasably connected to radial locations on the packing screw. Applied torque is transferred through a torque transfer engagement post, through the tool body to the engagement dogs and into the packing nut. A second torque transfer engagement post is smaller than the first engagement post. The shape of the tool body allows rotation in limited or confined space. A pump may be serviced at the wellsite by utilizing the packing screw removal tool to unthread the packing screw from the fluid end.

9 Claims, 9 Drawing Sheets



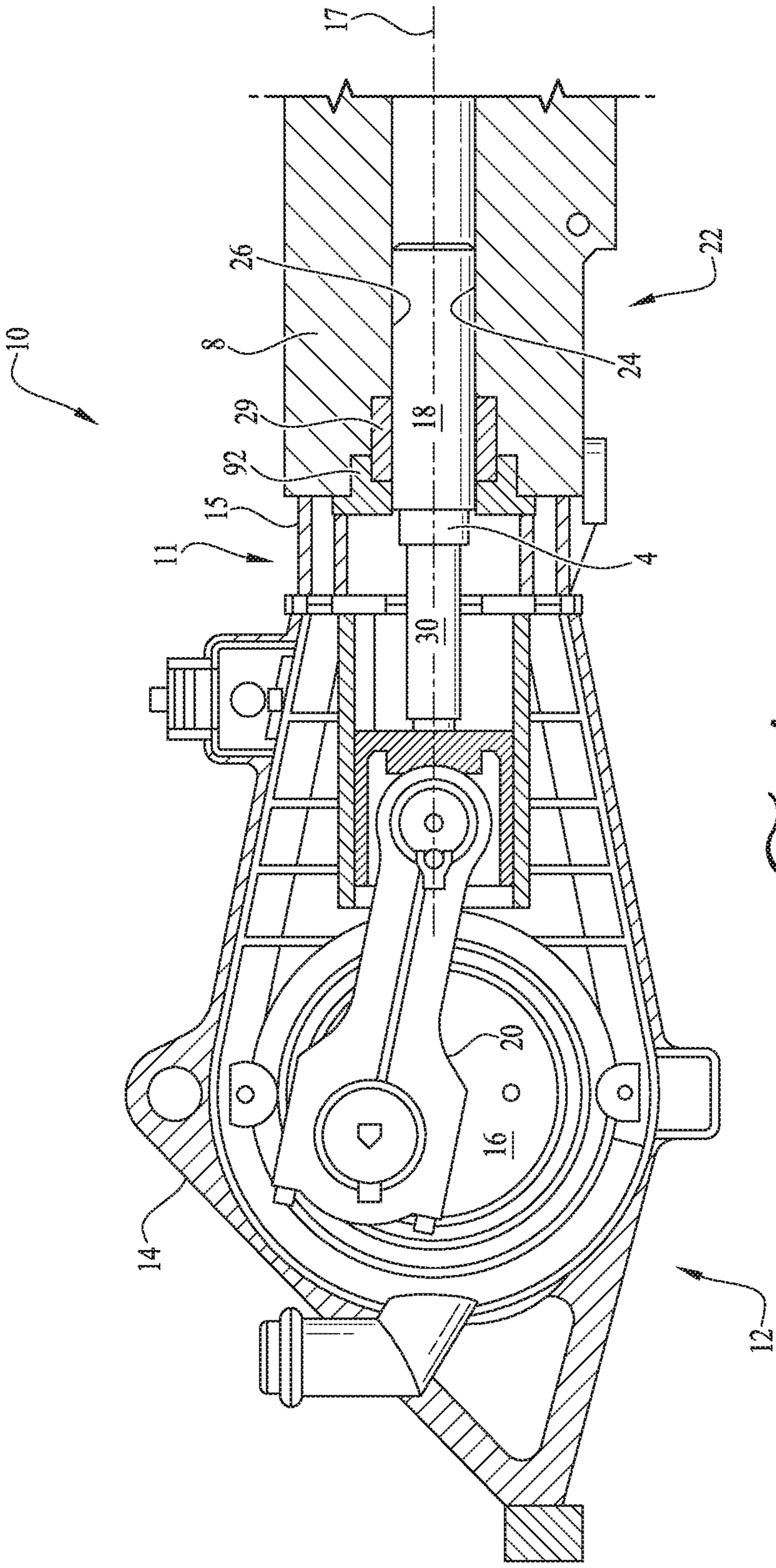
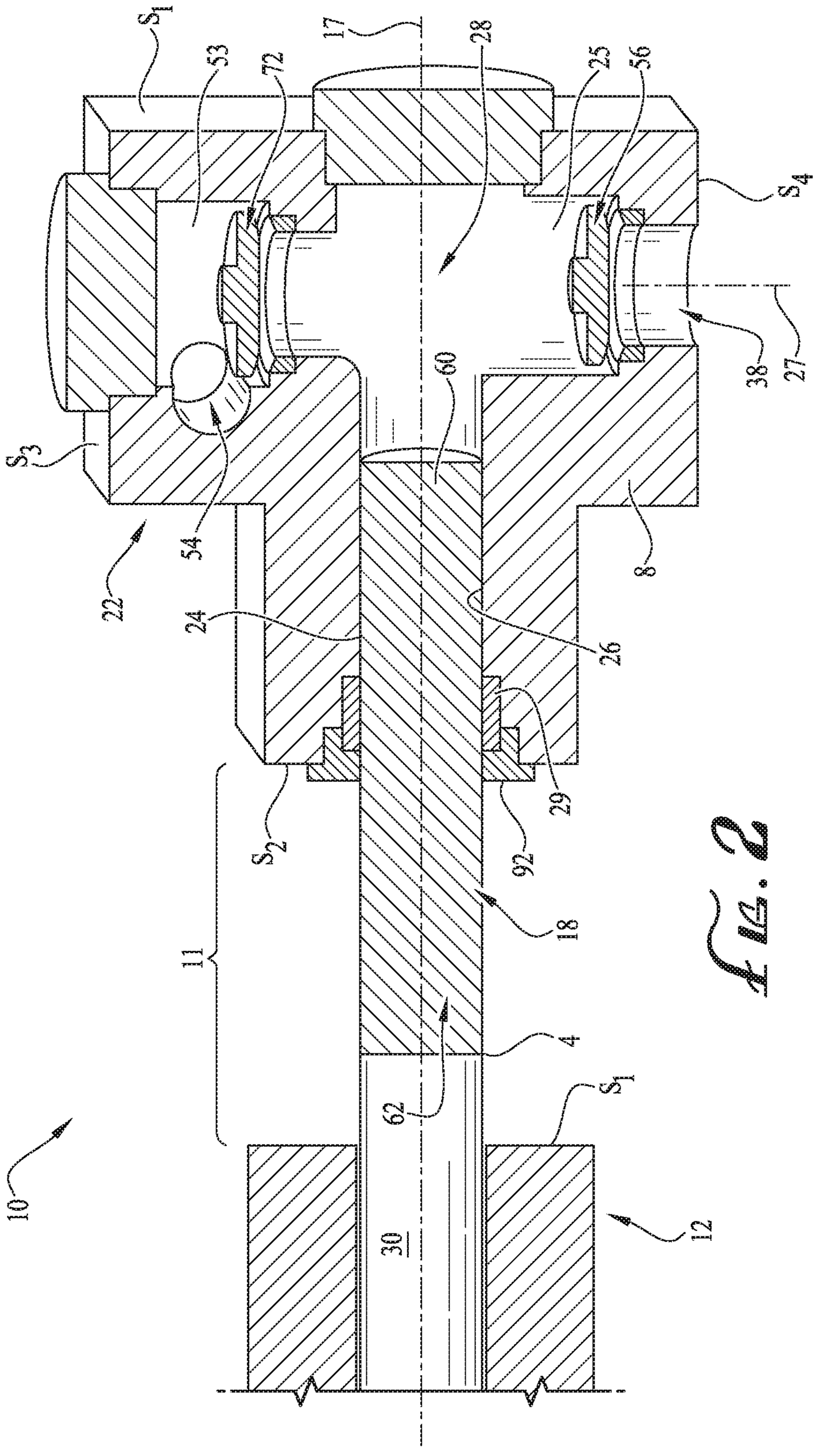


FIG. 1


S1
53
72
17
28
25
56
S4
38
27
60
S3
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24
26
8
29
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S2
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62
S1
10
30
12

FIG. 2

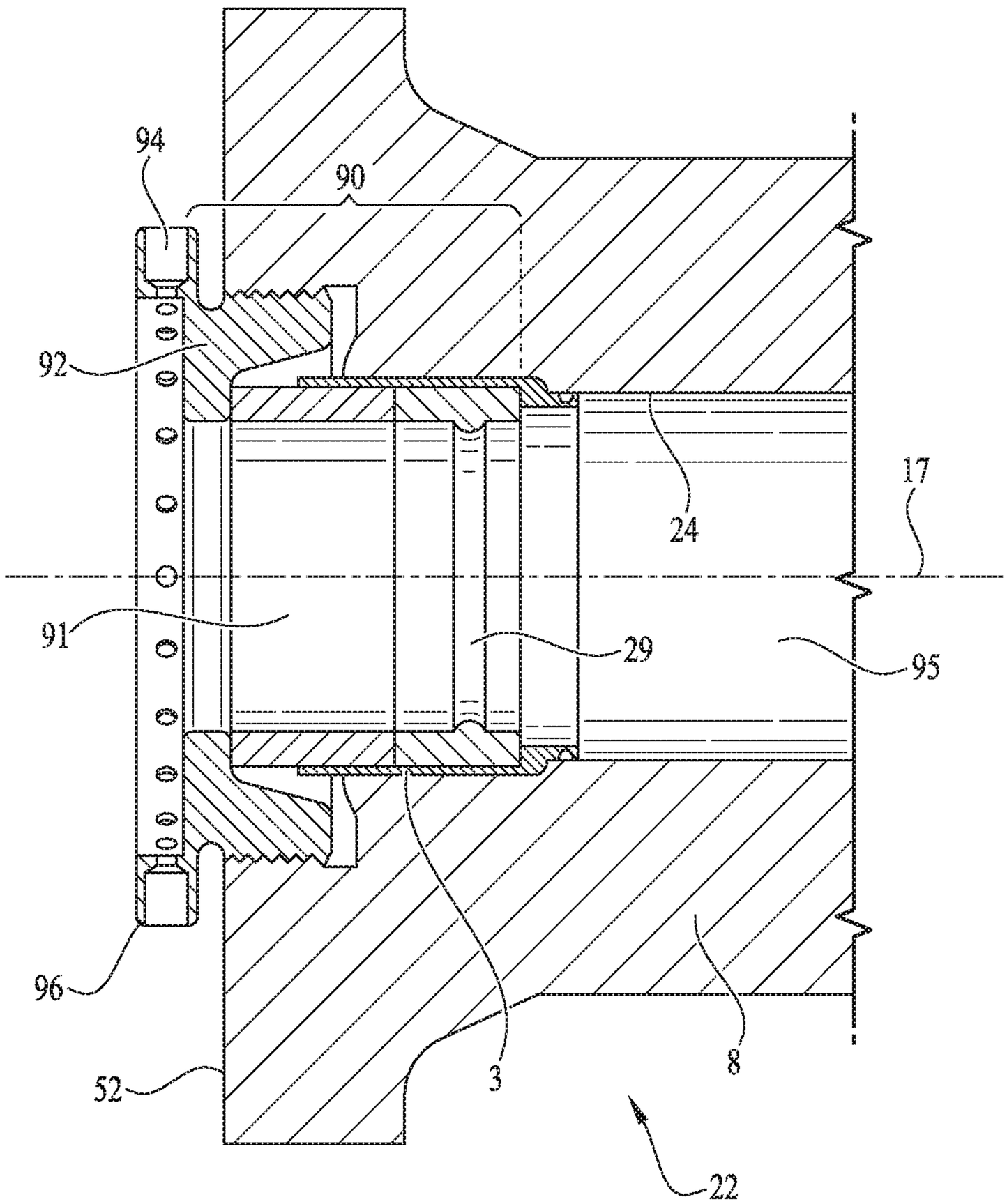

Fig. 3

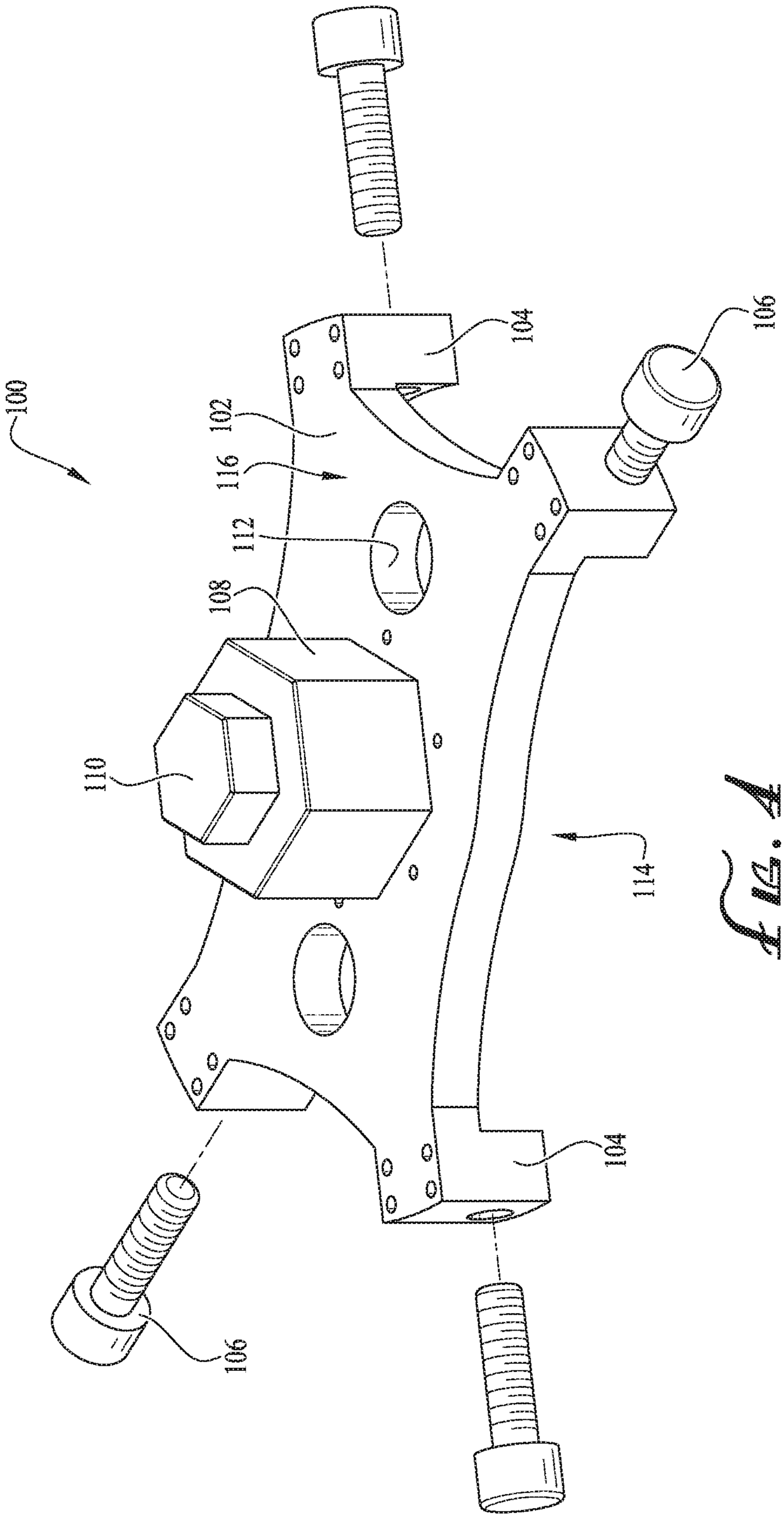

FIG. 1

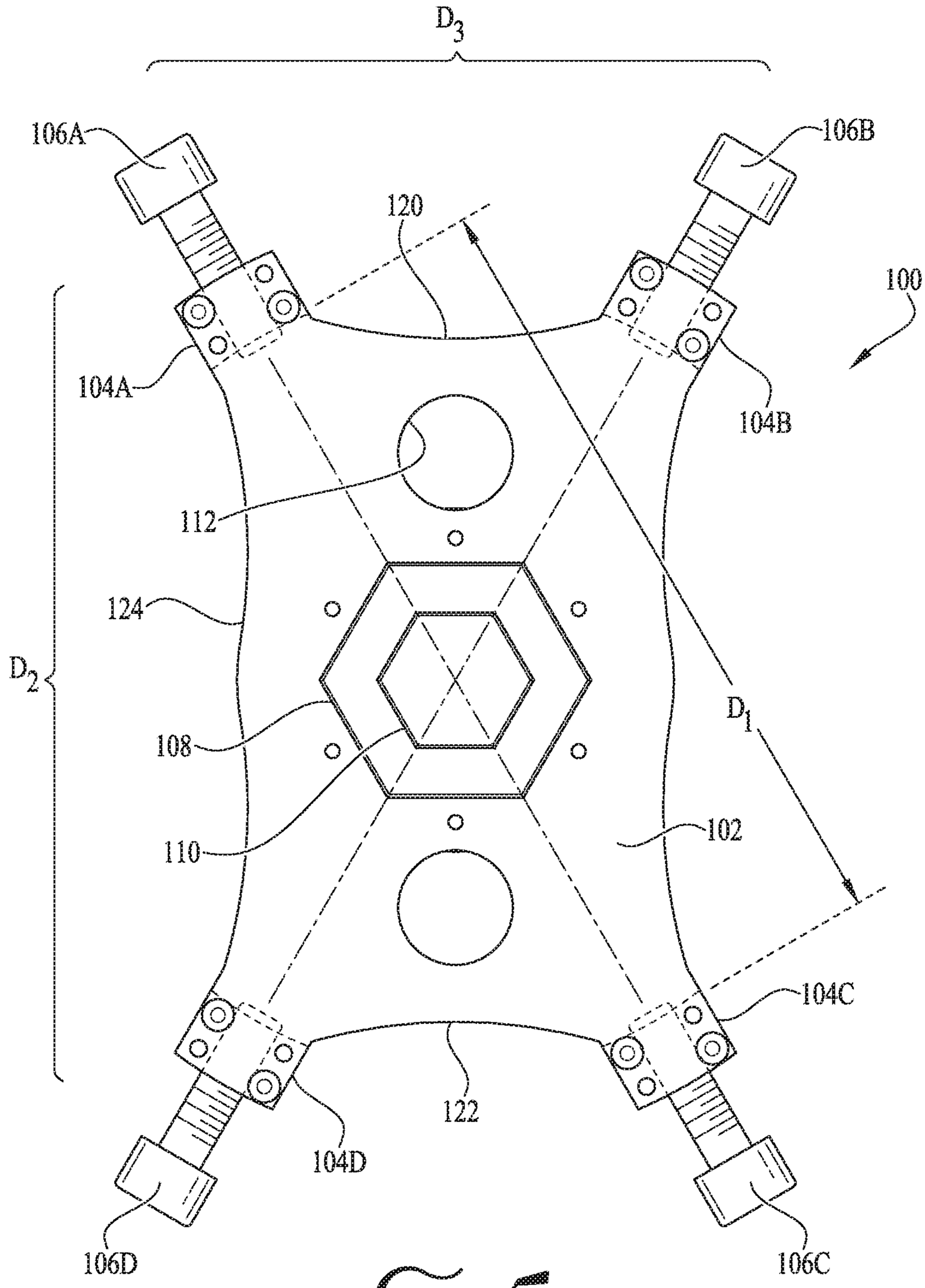
D3
106A
106B
120
100
104A
104B
112
124
D2
108
110
D1
102
104C
122
104D
106D
106C

FIG. 5

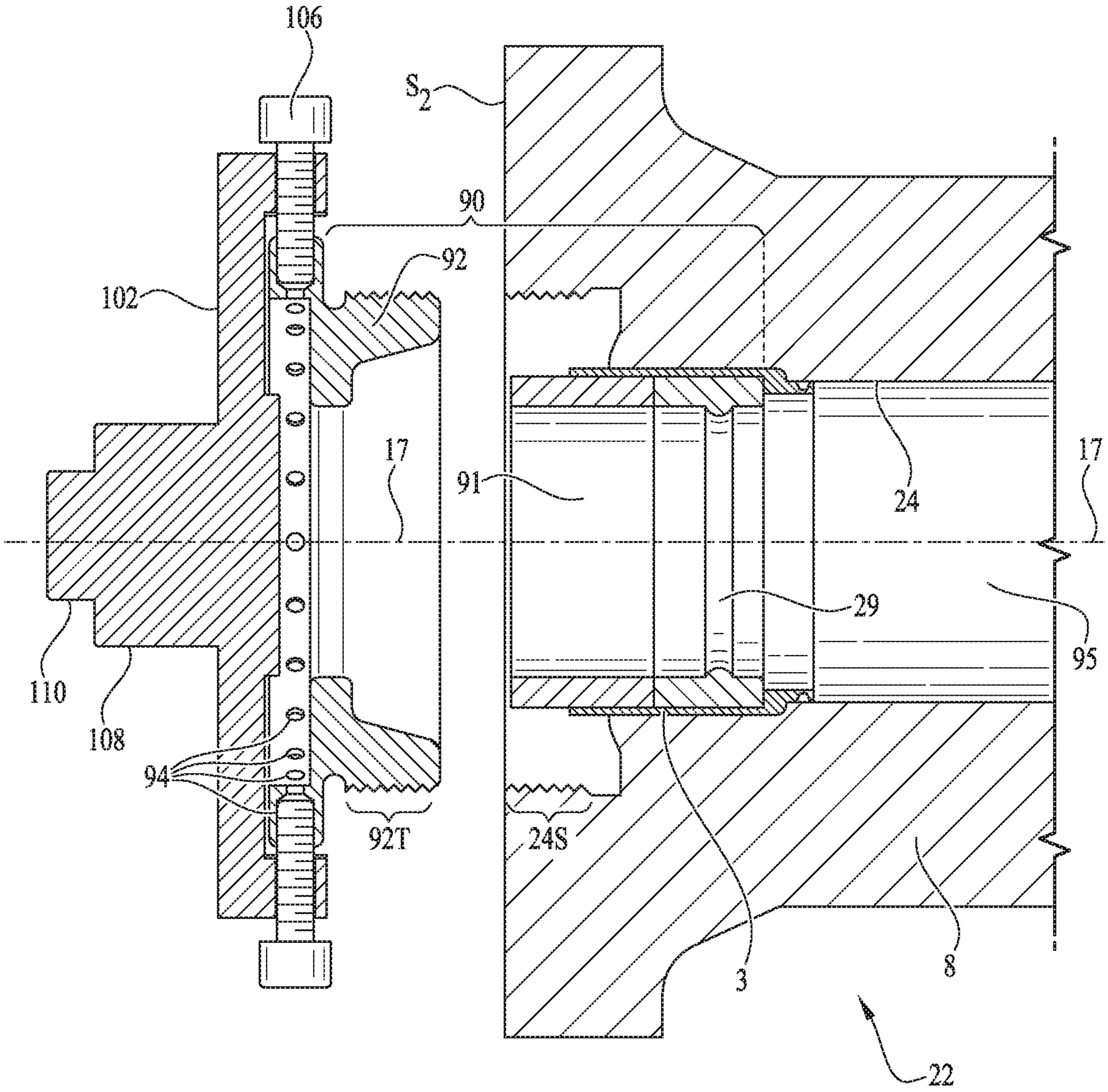

Fig. 6

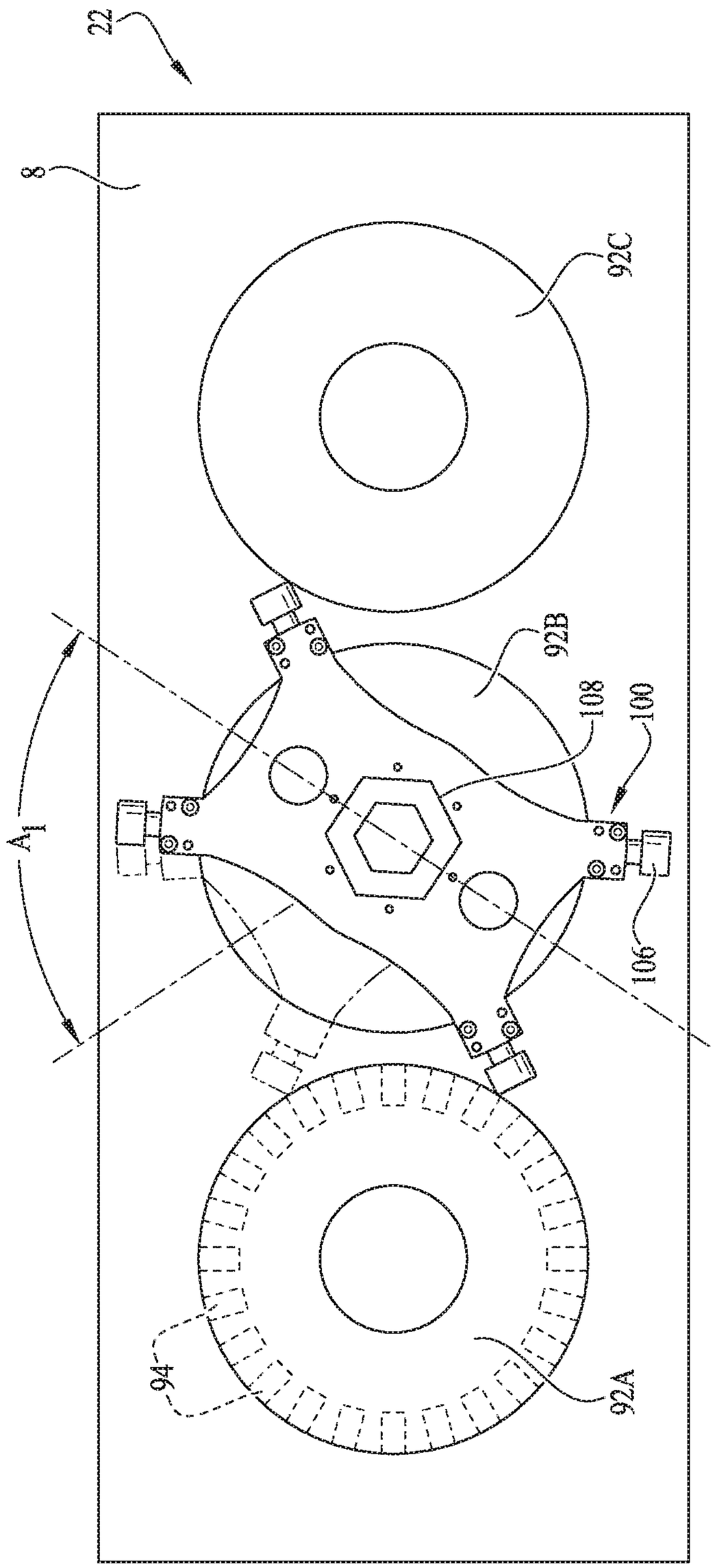

FIG. 7

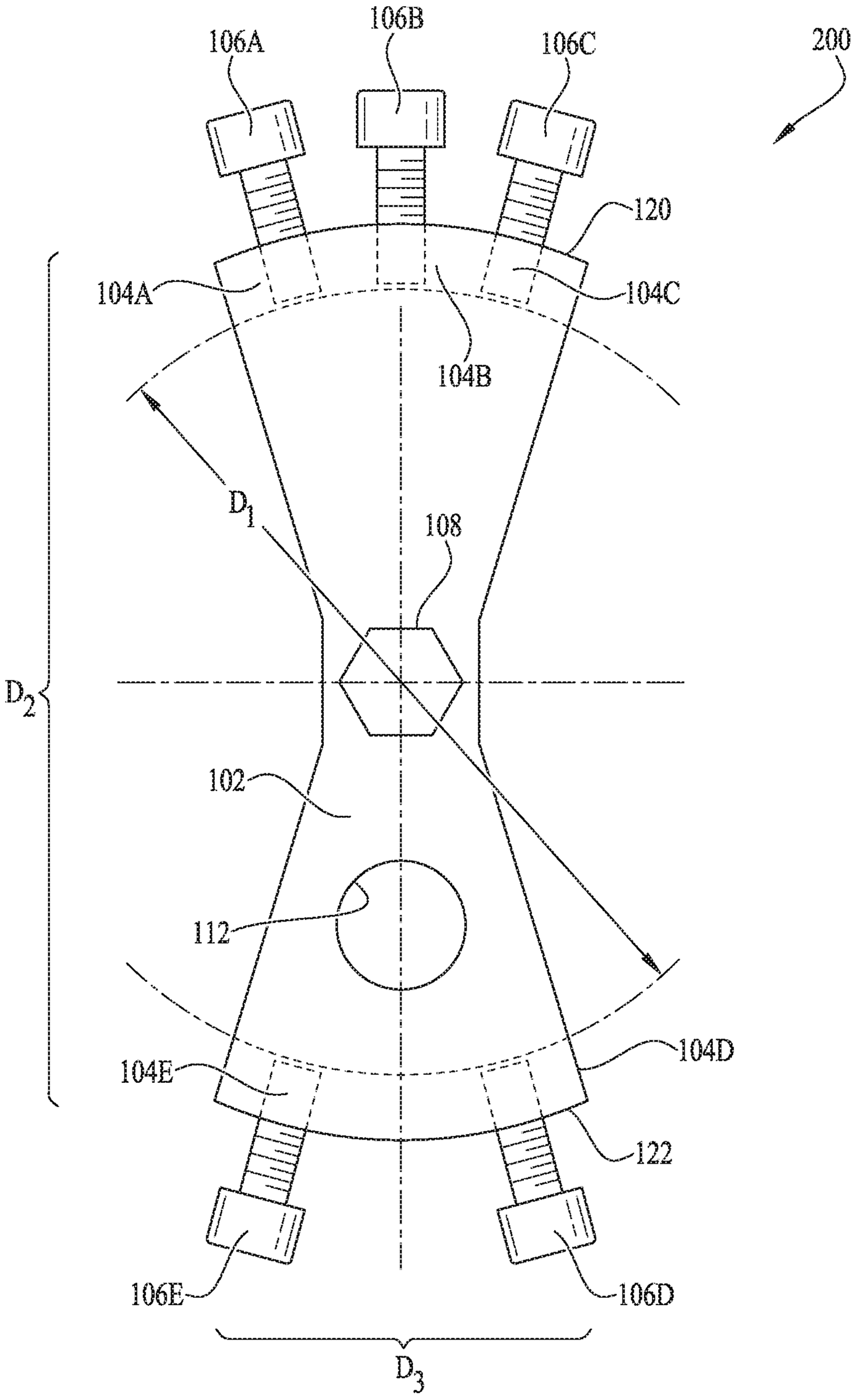
106A
106B
106C
200
120
104A
104C
104B
D_1
108
D_2
102
112
104E
104D
122
106E
106D
D_3

FIG. 8

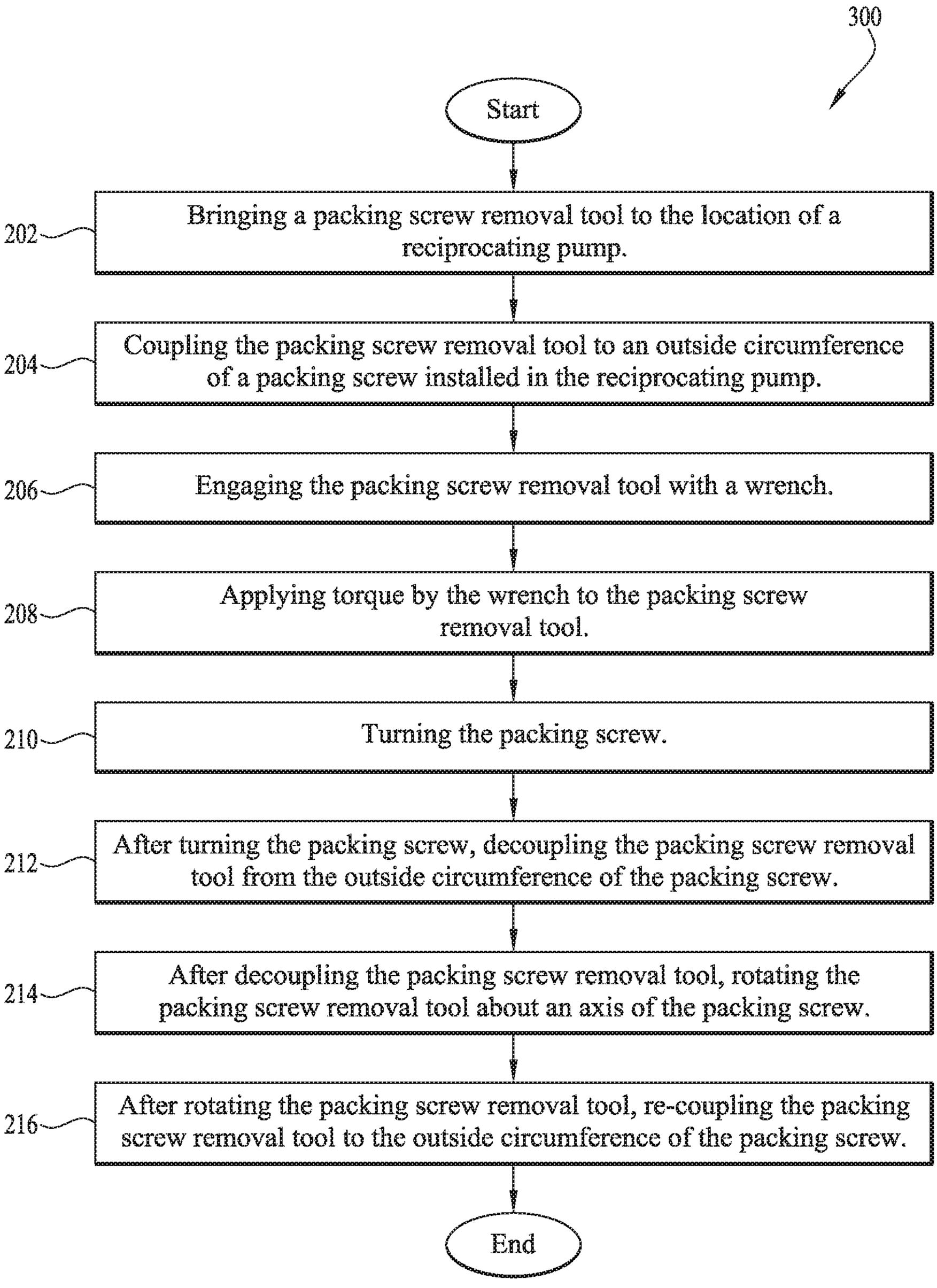
300
Start
202
Bringing a packing screw removal tool to the location of a reciprocating pump.
204
Coupling the packing screw removal tool to an outside circumference of a packing screw installed in the reciprocating pump.
206
Engaging the packing screw removal tool with a wrench.
208
Applying torque by the wrench to the packing screw removal tool.
210
Turning the packing screw.
212
After turning the packing screw, decoupling the packing screw removal tool from the outside circumference of the packing screw.
214
After decoupling the packing screw removal tool, rotating the packing screw removal tool about an axis of the packing screw.
216
After rotating the packing screw removal tool, re-coupling the packing screw removal tool to the outside circumference of the packing screw.
End

FIG. 9

PACKING SCREW REMOVAL TOOL

CROSS-REFERENCE TO RELATED APPLICATIONS

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE TO A MICROFICHE APPENDIX

Not applicable.

TECHNICAL FIELD

The present disclosure relates generally to a method and apparatus for repairing equipment that supplies pressurized fluids. More particularly, the present disclosure relates to methods and devices for accessing seals on reciprocating devices for pumping fluids into a wellbore.

BACKGROUND

High-pressure pumps having reciprocating elements such as plungers or pistons are commonly employed in oil and gas production fields for operations such as drilling and well-servicing. For instance, one or more reciprocating pumps may be employed to pump fluids into a wellbore in conjunction with activities including fracturing, acidizing, remediation, cementing, and other stimulation or servicing activities. Due to the harsh conditions associated with such activities, seals and other pump components are susceptible to wear and may be replaced during servicing and maintenance of the pump. Access to the seals and other pump components is made by removing a packing screw from the fluid end. One or more seals may be replaced on location. Seals may be replaced during a scheduled maintenance at a servicing location.

BRIEF SUMMARY OF THE DRAWINGS

For a more complete understanding of this disclosure, reference is now made to the following brief description, taken in connection with the accompanying drawings and detailed description, wherein like reference numerals represent like parts.

FIG. **1** is cut-away illustration of a pump power end of a pump, according to embodiments of the present disclosure.

FIG. **2** is a cut-away illustration of an exemplary reciprocating pump comprising a cross-bore pump fluid end, according to embodiments of the present disclosure.

FIG. **3** is a cut-away illustration of a pump comprising a packing assembly of this disclosure.

FIG. **4** is an isometric view of the packing screw removal tool according to embodiments of the present disclosure.

FIG. **5** is a top view of the packing screw removal tool according to embodiments of the present disclosure

FIG. **6** is a cut-away illustration of a pump comprising a packing assembly of this disclosure, with a packing screw removal tool according to embodiments of the present disclosure.

FIG. **7** is a front view of a pump fluid end with a packing screw removal tool according to embodiments of the present disclosure.

FIG. **8** is a top view of the packing screw removal tool according to embodiments of the present disclosure

FIG. **9** is a flow chart of a method according to an embodiment of the disclosure.

DETAILED DESCRIPTION

It should be understood at the outset that although an illustrative implementation of one or more embodiments is provided below, the disclosed systems and/or methods may be implemented using any number of techniques, whether currently known or in existence. The disclosure should in no way be limited to the illustrative implementations, drawings, and techniques illustrated below, including the exemplary designs and implementations illustrated and described herein, but may be modified within the scope of the appended claims along with their full scope of equivalents.

Oilfield pumps typically operate outside in adverse weather conditions pumping a variety of fluids at high pressures and high flow rates to perform oilfield and/or well-servicing operations. Oilfield pumps may encounter wide environmental temperature swings from the heat of the day to the cold of the night and from weather conditions from day to day. Oilfield pumps provide a wide variety of service operations at the well site. Such operations may include, but are not limited to, drilling operations, fracturing operations, perforating operations, fluid loss operations, primary cementing operations, secondary or remedial cementing operations, or any combination of operations thereof.

Typically a high-pressure oilfield pump utilizes a plunger design to pressurize the fluid. These pumps may operate with multiple plungers to achieve the desired flow rate at high pressure. A typical high-pressure oilfield pump may utilize 3, 4, 5, or more plungers to produce a steady flow of high pressure fluid to a wellbore. These pumps may pump a wide variety of servicing fluids into the wellbore. Non-limiting examples of suitable wellbore servicing fluid include a fracturing fluid (e.g., a particle-laden fluid, as described herein), a perforating fluid, a cementitious fluid, a sealant, a remedial fluid, a drilling fluid (e.g., mud), a spacer fluid, a gelation fluid, a polymeric fluid, an aqueous fluid, an oleaginous fluid, an emulsion, various other wellbore servicing fluid.

The plunger type pumps typically are constructed with a power end providing axial force to a fluid end. The fluid end utilizes a plunger to draw in fluid through a suction valve then pressurizes the fluid inside a pump chamber until the discharge valve opens to expel the fluid. A packing assembly comprised of a packing screw, a packing carrier, and packing provides a pressure seal for the reciprocating plunger.

The seals around the plunger on high-pressure oilfield pumps may erode and begin to leak fluid past the plunger. The combination of the erosive nature of the fluids, operating temperature of the pumps, the environmental temperature of the wellsite may erode the isolating ability of the packing until the packing begins to leak fluid, sand, and debris onto the packing carrier and packing screw. These pumps may be serviced at the wellsite to replace the packing and return the pump to operation servicing the well. However, the packing screw may become difficult to remove due to the fluid, sand, and debris encountered. In some cases, a welder may be called to the location to thermally loosen the packing screw by heating, then quenching the packing screw. In extreme cases, a welder may need to cut the packing screw out of the fluid end, running the risk that the pump may be irreparably damaged.

Disclosed herein is a packing screw removal tool for removal and installation of a packing assembly from a high-pressure oilfield pump. The packing assembly comprises a packing screw, packing carrier, and a packing. The packing screw removal tool engages the packing screw at multiple locations along the outside diameter to apply torque provided by a wrench to the packing screw threads. The applied torque may loosen the screw for removal and tighten the screw during installation.

Upon positioning the packing screw removal tool proximate the packing screw, adapter pins radially align with corresponding locations along the outside diameter of the packing screw. The adapter pins are installed radially from the packing screw removal tool into the packing screw and secured in place. The adapter pins may engage the packing screw in three or more locations. The radial engagement locations may be distributed about the circumference of the packing screw to help apply torque evenly to the packing screw.

In an alternate embodiment, the adapter pins radially align with corresponding locations along the inside diameter of the packing screw. The adapter pins are installed radially from the packing screw removal tool into the packing screw and secured in place. The adapter pins may engage the packing screw in three or more locations. The radial engagement locations may be distributed about the circumference of the packing screw to help apply torque evenly to the packing screw.

The packing screw removal tool fits into a confined space located between the pump power end and pump fluid end. The confined working space may also be measured by the distance between multiple packing screws on a multiple plunger pump. The packing screw removal tool may have a reduced profile to fit between the power end and the fluid end of the pump. The packing screw removal tool may also have a reduced width and an elongated profile that allows multiple adapter pins to be installed on opposite sides of the packing screw. The reduced width also allows the packing screw removal tool to rotate a partial turn before butting against an adjacent packing screw. The packing screw removal tool may be removed, rotated, and installed for additional partial turns.

In an embodiment, the packing screw removal tool has a large wrench engagement feature on the side opposite the packing screw for a large wrench and a smaller wrench engagement feature for a smaller wrench. The large wrench engagement feature may be used with a powered wrench assembly such as an electrical power wrench or a hydraulically powered wrench. The smaller wrench engagement feature may be used with a manual wrench. The powered wrench may be utilized to apply a greater amount of torque, for example, 4000 ft-lb compared to a manual wrench.

Disclosed herein is a method of maintaining a high-pressure pump at a wellsite to return the pump to an operating condition servicing the well. The pumping crew discontinues pumping operations, isolates the pump from the high-pressure manifold, and disconnects the pump from the high-pressure manifold. The high-pressure pump may be moved to a safe location at the wellsite or returned to a servicing location. The packing screw removal tool may be attached to the packing screw on the backside of the pump. Torque may be applied to the large wrench location on the packing screw removal tool to turn the packing screw a partial turn. The packing screw removal tool may be removed and installed for additional partial turns. The pack screw and packing are removed from the fluid end. A new set of packing is installed with the packing screw. The packing screw removal tool may be used to apply torque to install the packing screw. The packing screw removal tool may then be removed from the packing screw. The high-pressure pump returns to the wellsite, is connected to the high-pressure manifold, and commences pumping operations.

Turning now to FIG. **1** a cutaway illustration of an exemplary pump **10** of this disclosure, showing an exemplary pump power end **12**, integrated via integration section **11** with a pump fluid end **22**, wherein the pump power end **12** is operable to reciprocate the reciprocating element **18** within a reciprocating element bore **24** of the pump fluid end **22**. Briefly, for example, the pump power end **12** may include a rotatable crankshaft **16** to power a crank arm/connecting rod **20** attached to a pushrod **30** that is coupled by mechanical linkages **4** to at least one reciprocating element **18** (e.g., a plunger or piston). Additionally, an engine (e.g., a diesel engine), motor, or other suitable power sources may be operatively connected to the crankshaft **16** (e.g., through transmission and driveshaft) and operable to actuate rotation thereof. In operation, rotation of the crankshaft **16** induces translational movement of the crank arm/connecting rod **20**, thereby causing the pushrod **30**, mechanical linkage **4**, and reciprocating element **18** to extend and retract along a flow path, which may generally be defined by a central axis **17** within a reciprocating element bore **24** (sometimes referred to herein for brevity as a "reciprocating element bore **24**" or simply a "bore **24**", although not wishing to be limited to a particular reciprocating element **18**). Pump **10** of FIG. **1** is typically mounted on a movable structure such as a semi-tractor trailer or skid, and the moveable structure may contain additional components, such as a motor or engine (e.g., a diesel engine), that provides power (e.g., mechanical motion) to the pump power end **12** (e.g., a crankcase comprising a crankshaft **16** and related connecting rods **20**).

Of course, numerous other components associated with the pump power end **12** of the pump **10** may be similarly employed, and therefore, fall within the purview of the present disclosure. Furthermore, since the construction and operation of components associated with pumps of the sort depicted in FIG. **1** are well known and understood, discussion of the pump **10** will herein be limited to the extent necessary for enabling a proper understanding of the disclosed embodiments.

The pump fluid end **22** is integrated with the pump power end **12** via the integration section **11**, such that pump power end **12** is operable to reciprocate the reciprocating element **18** within a reciprocating element bore **24** (FIGS. **1-2**) of the pump fluid end **22**. The reciprocating element bore **24** is at least partially defined by a cylinder wall **26**. As described further hereinbelow with reference to FIG. **2**, pump fluid end **22** can be a cross-bore pump fluid end **22** or, alternatively, an in-line or "concentric" bore pump fluid end. As utilized herein, cross-bore pump fluid ends can comprise "T-bore" pump fluid ends, "X-bore" (e.g., cross-shaped bore) pump fluid ends, or "Y-bore" pump fluid ends.

Turning now to FIG. **2**, a cross-bore pump fluid end **22** is illustrated engaged with a reciprocating element **18**. The pump **10** includes at least one fluid inlet **38** for receiving fluid from a fluid source, e.g., a suction line, suction header, storage or mix tank, blender, discharge from a boost pump such as a centrifugal pump, etc. The pump **10** also includes at least one discharge outlet **54** for discharging fluid to a discharge source, e.g., a flowmeter, pressure monitoring and control system, distribution header, discharge line, wellhead, discharge manifold pipe, and the like.

One or more seals **29** (e.g., "o-ring" seals, packing seals, or the like), also referred to herein as 'primary' reciprocating element packing **29** may be arranged around the reciprocating element **18** to provide sealing between the outer walls of the reciprocating element **18** and the cylinder walls **26** defining at least a portion of the reciprocating element bore **24**. Packing **29** can be any suitable packing known to those of skill in the art and with the help of this disclosure. The packing **29** may comprise an elastomeric material, a plurality of rings of elastomeric material, may comprise one, two, three, four, or more of rings of elastomeric material. Skilled artisans will recognize that the seals may comprise any suitable type of seals, and the selection of seals may depend on various factors, e.g. fluid, temperature, pressure, etc.

A pump **10** of this disclosure may have limited access to packing **29** in FIG. **2** due to the location within the integration section **11**. The integration section **11** can be positioned in a space between the pump fluid end **22** and the pump power end **12**, and can be safeguarded (e.g., from personnel) via a cover **15**. Locations described as front S**1**, back S**2**, top S**3**, and bottom S**4** can be relative to a surface (e.g., a trailer bed, the ground, a platform, etc.) upon which the pump **10** is located, a bottom S**4** of the pump fluid end being proximal the surface (e.g., trailer bed) upon which the pump **10** is located. Generally, due to the size and positioning of pump **10**, the front S**1** and top S**3** of the pump fluid end **22** are more easily accessible than a back S**2** or bottom S**4** thereof. In a similar manner, a front of pump **10** is distal the pump power end **12**, and the back of the pump **10** is distal the pump fluid end **22**.

FIG. **3** is a cut-away illustration of a packing assembly **90** of this disclosure in pump fluid end **22**. Packing assembly **90** comprises a packing screw **92**, a packing carrier **91**, and a packing **29**. Packing screw **92**, packing carrier **91**, and packing **29** are cylindrical and have a width measured an axial distance along a central axis that is less than the distance between the pump power end **12** and the pump fluid end **22** to allow for removal. The packing screw **92** has radial locations **94** evenly distributed about the circumference of the outer surface **96**. The radial locations **94** may be drilled holes, broached square or hex shapes, castellation, or other similar features.

Turning now to FIG. **4**, a packing screw removal tool **100** for removal or installation of a packing screw is described. The packing screw removal tool **100** comprises main body **102**, dogs **104**, locking pins **106**, the central engagement feature **108**, the secondary engagement feature **110**, and apertures **112**. The main body **102** may be made from plate-like material typically having two substantially parallel faces/sides: a packing screw engaging side **114** (facing the packing screw when in use) and a lever engaging side **116** (facing away from the packing screw when in use).

The packing screw engagement side **114** of the main body **102** has dogs **104** projecting outwards and spaced apart to allow engagement with the packing screw **92**. The dogs **104** may be formed in place (machined from a single piece of material, extruded, or sintered) with the main body **102** or may be attached to the main body **102** by welding, brazing, or fasteners such as screws or bolts. The dogs **104** retain locking pins **106** in place. The locking pins **106** may be installed from the outside surface of the dogs **104** to engage radial locations **94** along the outer surface **96** of the packing screw **92**. The locking pins **106** may be screws, bolts, pins, latches, or any other type of fastener known to the arts.

In an alternate embodiment, the locking pins **106** may be installed from the inside surface of the dogs **104** to engage radial locations **94** along the inner surface of the packing screw **92**.

In an embodiment, the lever engaging side **116** of the main body **102** has a central engagement feature **108** and secondary engagement feature **110** projecting outwards. In some contexts, the engagement feature may be referred to as a torque transfer engagement post. The central engagement feature **108** may engage a manual tool or an electrically or hydraulically powered mechanical assembly (powered wrench) for the application of torque. The central engagement feature **108** may engage a manual tool, for example, a hand wrench (not shown) for the application of torque. The central engagement feature **108** may be a hex nut with six equally spaced parallel sides for engagement with a standard-sized (ANSI or metric) wrench. The central engagement feature **108** projection length would typically establish full engagement with the manual wrench or the powered wrench. The lever engaging side **116** of the main body **102** has a secondary engagement feature **110** projecting outwards from the central engagement feature **108**. The secondary engagement feature **110** is typically smaller in size to engage a smaller standard-sized (ANSI or metric) wrench. The secondary engagement feature **110** allows for smaller wrench use when moderate torque is desired to rotate the packing screw. Even though the central engagement feature **108** and secondary engagement feature **110** are described as a hex nut the central engagement feature **108** and secondary nut could be made to any similar fastener shape: square, pentagon, hex, double-square, double-hex, Torx, external Torx, Pentalobe, or other similar shapes.

An alternate embodiment for the secondary engagement feature **110** may be an inward projection of an engagement shape such as a hex socket projected into the central engagement feature **108**. The hex socket shape of the secondary engagement feature **110** would then engage a hex key, Allen key, or Allen wrench. A hex key is typically manufactured with tight tolerances to fit tightly into the corresponding socket shape. Even though the secondary engagement feature **110** inward projection is described as a hex socket, the inward projection could be made to any similar socket shape: square, pentagon, hex, double-square, double-hex, Torx, external Torx, pentalobe, or other socket shapes.

The shape of the packing screw removal tool **100**, in an embodiment, is further discussed with reference to FIG. **5** with a top view showing distance D**1** between two dogs **104** spaced about 180 degrees apart. The distance D**1** between dogs **104** allows for a slip fit or a fit with an allowance for movement, between the outside diameter of the packing screw defined by the outer surface **96** in FIG. **3** and the dogs **104**. The packing screw removal tool **100** has four locking pins **106** with locking pin **106**A and locking pin **106**B radially spaced apart by about 60 degrees around the central axis perpendicular to the flat side of the main body **102**. Locking pin **106**C is located about 120 degrees from locking pin **106**D about the perpendicular axis. Locking pin **106**D is located about 60 degrees from locking pin **106**C, and the first locking pin **106**A is located about 120 degrees from locking pin **106**D. The distance D**2** is measured across the long side of the packing screw removal tool **100** and defines the length of the tool spanning the outside diameter of the packing screw **92**. The distance D**3** defines the width of the short side **120** of the packing screw removal tool **100** between the locking pins rotated about 60 degrees apart.

In an embodiment, the angle between the locking pins **106**A and **106**B on the short side of the packing screw

removal tool **100** may be about 60 degrees, about 50 degrees, about 45 degrees, or about 30 degrees and function as described. The locking pins **106** align with the radial locations **94** on the packing screw **92**. The angle between the locking pins **106**A and **106**B on the short side of the packing screw removal tool **100** could be any acute angle and function as described.

The packing screw removal tool **100** transmits the torque applied to the central engagement feature **108** or alternatively the secondary engagement feature **110** through the main body **102** to the dog **104**, to the locking pins **106**, and into the packing screw radial locations **94**. The packing screw removal tool **100** distributes the applied torque to the number of locking pins **106** installed in the packing screw radial locations **94** on the packing screw **92**. The angular location of the locking pins **106** aligns with the angular location of the packing screw radial locations **94** along the outside diameter of the packing screw **92**. Alternatively, the angular location of the locking pins **106** aligns with the angular location of the packing screw radial locations **94** along the inside diameter of the packing screw **92**. The aligned dogs and packing screw radial locations may be spaced 70 degrees or less apart on the short side of the tool with the distance D**3**. The packing screw removal tool **100** may have 2 or more dogs **104** and locking pins **106** on the short side of the tool that aligns with packing screw radial locations **94**. The packing screw removal tool **100** may have the same number of dogs **104** and locking pins **106** on opposite short sides of the main body **102**. The packing screw removal tool **100** may have a different number of dogs **104** and locking pins **106** on opposite short sides of the main body **102**.

Turning now to FIG. **6**, a packing assembly **90** is installed in the reciprocating element bore **24** of the fluid end body **8**. The packing assembly **90** is comprised of packing screw **92**, primary packing **29**, and packing carrier **91** installed in packing sleeve **3** inside the reciprocating element bore **24**. A high level of torque may need to be applied to remove the packing screw **92** to access the primary packing **29**. A packing screw removal tool **100** is installed on the packing screw **92** in FIG. **3** and FIG. **6** by aligning the locking pins **106** to the packing screw radial locations **94** and radially installing the locking pins **106** into the packing screw **92**. Torque may be applied to the central engagement feature **108** or the secondary engagement feature **110** to transfer torque through the locking pins **106** installed into the packing screw **92** to unthread the packing screw **92** from the fluid end body **8**. A packing screw removal tool **100** may be used on a multiple plunger pump with 3 or more plungers, as shown in FIG. **7**. The packing screw removal tool **100** is placed on packing screw **92**B that is located between packing screws **92**A and **92**C on pump fluid end **22**. The packing screw removal tool **100** may rotate a partial turn of angular distance μl when torque is applied to central engagement feature **108** or secondary engagement feature **110**. The angular distance μl may be defined as the distance the centerline of the packing screw removal tool **100** rotates about the central engagement feature **108**. The angular distance is constrained by the width of the packing screw removal tool **100** defined by distance D**3** and the proximity of packing screw **92**A, **92**B, and **92**C. The locking pins **106** may be disengaged from the packing screw **92**B and the packing screw removal tool **100** may be rotated and reinstalled a second time for another partial rotation defined as angular distance μl. Although the packing screw removal tool **100** is shown installed on the outside of the packing screw **92**, it is understood that the packing screw removal tool **100** could be installed on the inside of the packing screw **92**.

An alternate embodiment of a packing screw removal tool **200** shown in FIG. **8** has three dogs **104**A-C and locking pins **106**A-C, on the short side **120** and two dogs **104**D-E and locking pins **106**D-E on the opposite short side **122**. The three dogs **104**A-C and locking pins **106**A-C on the short side **120** may align with sequential corresponding packing screw radial location **94** on the packing screw **92**. For example, if the packing screw **92** has 36 radial locations **94** spaced 10 degrees apart, three dogs **104**A-C and locking pins **106**A-C may be spaced 10 degrees apart; dog **104**B is rotated 10 degrees from dog **104**A and dog **104**C is rotated 10 degrees from **104**B. Likewise, if the packing screw **92** has 24 radial locations **94** spaced 15 degrees apart, three dogs **104**A-C and locking pins **106**A-C may be spaced apart 15 degrees; dog **104**B is rotated 15 degrees from dog **104**A and dog **104**C is rotated 15 degrees from **104**B. The two dogs D-E and locking pins D-E on the opposite short side **122** may align with corresponding packing screw radial locations **94** on the packing screw **92** that are spaced a multiple of the angular location. For example, if the packing screw **92** has 36 radial locations **94** spaced 10 degrees apart, two dogs **104**D-E and locking pins **106**D-E may be spaced 20 degrees, 30 degrees, or some other multiple of 10 degrees apart. Likewise, if the packing screw **92** has 24 radial locations **94** spaced 15 degrees apart, the two dogs **104**D-E and locking pins **106**D-E may be spaced 15 degrees, 30 degrees, or some other multiple of 15 degrees apart. One or more of the three dogs **104** A-C on the short side **120** may be spaced a multiple of the angular location without deviating from the scope of the embodiment. In an alternate embodiment, the locking pins **106** A-E could be installed from the inside of the dogs **104** A-E attach to the inside of the packing screw **92**.

A pump **10** may begin losing pressure pumping ability, and fluid may begin leaking from packing **29** due to extended pumping service, erosive nature of the fluid, fluid composition, environmental condition, or a combination of factors. The fluid may begin to leak from the pump chamber **28**, through the packing **29**, past the packing carrier **91**, and out around the packing screw **92**. Any fluid leak will reduce the ability of the pump to pressurize the fluid and reduce the flow rate. In addition, the leaking fluid may pose an environmental hazard that requires clean up.

The pumping crew may desire to repair the leaking packing at the wellsite to return the pump **10** to servicing the well. The pumping crew would cease pumping operations and isolate the pump from a high-pressure line or a high-pressure manifold connected to the wellhead. The pump **10** would then be disconnected from the supply line and high-pressure line and moved a safe distance away.

The pumping crew may prepare the pump **10** for removal of the packing screw **92** by disconnecting various components, cleaning spills, or removing parts. The pumping crew may remove the mechanical linkage **4** and the reciprocating element **18** from the pump **10** for access to the packing assembly **90**.

A packing assembly **90** can be removed from pump fluid end **22** by applying torque with the packing screw removal tool **100** to unscrew the packing screw **92**. The packing screw removal tool **100** is aligned with the radial locations **94** along the packing screw **92**, and the locking pins **106** are radially engaged with the radial locations **94**. Torque is applied to the central engagement feature **108** or the secondary engagement feature **110** to unthread the packing screw **92** a partial turn defined by A**1** in the limited space

between packing screws. The packing screw removal tool may be decoupled from the packing screw **92** by disengaging the locking pins **106** from the radial locations. The packing screw removal tool **100** may then be aligned a second time for a second partial turn. The packing screw removal tool **100** may be engaged for multiple partial turns until the packing screw **92** unthreads from the pump fluid end body **8**. That is, the packing screw **92** can be decoupled from the pump fluid end body **8** (e.g., by dethreading the threads on the portion **92**T of the outside diameter of packing screw **92** that is threaded from the corresponding threads on the portion **24**S of the inside diameter of the reciprocating element bore **24** and/or packing sleeve **95** that is threaded), removing packing screw **92** from reciprocating element bore **24**, via the back S**2** of pump fluid end **22**, removing packing carrier **91** from reciprocating element bore **24** via the back S**2** of pump fluid end **22**, and removing packing **29** from reciprocating element bore **24** via the back S**2** of pump fluid end **22**. The pumping crew may then complete the servicing of the pump **10** on location by replacing one or more eroded parts such as the packing **29**, the packing carrier **91**, and the packing screw **92**.

Turning now to FIG. **9**, a method **300** is described. In an embodiment, the method **300** comprises a method of removing a packing screw with a packing screw removal tool. At block **202**, the method **300** comprises bringing a packing screw removal tool **100** to the location of a reciprocating pump. The location of the pump **10** may be a wellsite or a service location. The packing screw removal tool **100** may be brought with the pump to a wellsite or transported to the wellsite on a separate trip. The packing screw removal tool **100** may be located at a servicing location or brought to the servicing location.

At block **204**, the method **300** comprises coupling a packing screw removal tool to an outside circumference of a packing screw installed in the reciprocating pump. The packing screw removal tool **100** is aligned with the radial locations **94** along the packing screw **92**, and the locking pins **106** are radially engaged with the radial locations **94**. Alternately, the packing screw removal tool may be coupled to the inside of a packing screw and the locking pins **106** radially engage with the radial locations **94**.

At block **206**, the method **300** comprises engaging the packing screw removal tool with a wrench. A manual wrench or powered wrench may engage the central engagement feature **108**. A manual wrench or a powered wrench may engage the secondary engagement feature **110**. In an alternate embodiment, a hex key or an Allen wrench may engage the secondary engagement feature **110**.

At block **208**, the method **300** comprises applying torque by the wrench to the packing screw removal tool. Torque is applied with either a powered wrench or a manual wrench to the central engagement feature **108** or the secondary engagement feature **110**.

At block **210**, the method **300** comprises turning the packing screw. The packing screw is rotated by the torque applied to the engagement feature on the packing screw removal tool **100**.

At block **212**, the method **300** comprises after turning the packing screw, decoupling the packing screw removal tool from the outside circumference of the packing screw. In an embodiment, the four locking pins **106** are radially disengaged from the packing screw radial locations **94**. Alternatively, the packing screw removal tool may be decoupled form the inside circumference of the packing screw.

At block **214**, the method **300** comprises after decoupling the packing screw removal tool, rotating the packing screw removal tool about an axis of the packing screw. The packing screw removal tool **100** is rotated about the center axis of the packing screw **92** to realign the dogs **104** with the packing screw radial locations **94**.

At block **216**, the method **300** comprises after rotating the packing screw removal tool, re-coupling the packing screw removal tool to the outside circumference of the packing screw. The packing screw removal tool **100** is aligned with the radial locations **94** along the packing screw **92**, and the locking pins **106** are radially engaged with the radial locations **94**.

A packing assembly of this disclosure can be assembled in a pump fluid end **22** by inserting the packing **29** into reciprocating element bore **24** (or a sleeve inserted therein) from back S**2** of pump fluid end **22**, packing carrier **91** can be inserted into reciprocating element bore **24** from back S**2** of pump fluid end **22**, and packing screw **92** can be inserted into reciprocating element bore **24** from back S**2** of pump fluid end **22**. Once packing screw **92** is inserted, it can be coupled with pump fluid end body **8** (e.g., via threading the threads on the portion **92**C of the outside diameter of packing screw **92** that is threaded with corresponding threads on the portion **24**A of the inside diameter of the reciprocating element bore **24** and/or packing sleeve **95** that is threaded). Initially, the threading of the threads may require little or no torque until the packing screw **92** encounters packing carrier **91** or, in some cases, the fluid end body **8**. The packing screw removal tool **100** is aligned with the radial locations **94** along the packing screw **92**, and the locking pins **106** are radially engaged with the radial locations **94**. Torque is applied to the central engagement feature **108** or the secondary engagement feature **110** to apply torque to retain the packing screw **92** to the fluid end body **8**. Once coupled, packing screw **92** retains packing carrier **91** and packing **29** within reciprocating element bore **24** (and/or within a packing sleeve **95** therein).

As noted hereinabove, the packing screw removal tool **100** may be utilized on a packing screw **92** found on a multi-cylinder pump comprising multiple cylindrical reciprocating element bores **24** and corresponding components. In embodiments, the pump **10** is a Triplex pump in which the pump fluid end **22** comprises three reciprocating assemblies, each reciprocating assembly comprising a suction valve assembly **56**, a discharge valve assembly **72**, a pump chamber **28**, a fluid inlet **38**, a discharge outlet **54**, and a reciprocating element bore **24** within which a corresponding reciprocating element **18** reciprocates during operation of the pump **10** via connection therewith to a (e.g., common) pump power end **12**. In embodiments, the pump **10** is a Quintuplex pump in which the pump fluid end **22** comprises five reciprocating assemblies. In a non-limiting example, the pump **10** may be a Q-10™ Quintuplex Pump or an HT-400™ Triplex Pump, produced by Halliburton Energy Services, Inc.

Those of ordinary skill in the art will readily appreciate various benefits that may be realized by the present disclosure. For instance, the utilization of a packing screw removal tool **100**, as described herein, can facilitate removal and replacement of components of packing assembly **90** within pump fluid end **22**. Due to utilization of a packing assembly **90** as described herein, wherein the removal of the packing screw **92** from the pump fluid end **22** to remove and replace packing **29**, packing carrier **91** without damaging the pump fluid end **22**. In embodiments, utilization of a set of locking pins **106** to engage with radial locations **94** on the packing screw distributes torque along the packing screw **92**. The locking pins **106** align and releasably engage with the

packing screw radial locations **94**. In embodiments, two locking pins **106** may be located at 60 degrees on the short side of the packing screw removal tool **100**, and two locking pins **106** may be located 180 degrees from the first set.

A power wrench may apply torque to the central engagement feature **108** to transmit torque through the main body **102** to the dog **104** to the locking pins **106** and into the packing screw radial locations **94** to unthread the packing screw **92** form the fluid end body **8**. A manual wrench may apply torque to a secondary engagement feature **110** to transmit torque through the main body **102** to the dog **104** to the locking pins **106** and into the packing screw radial locations **94** to unthread the packing screw **92** form the fluid end body **8**. The torque applied to the packing screw removal tool **100** may rotate the packing screw **92** a partial turn. The packing screw removal tool **100** may be disengaged from the packing screw **92** and reengaged for multiple partial turns to unthread the packing screw **92** from the fluid end body **8**. Accordingly, utilization of the packing screw removal tool **100** of this disclosure on a packing screw **92** in a pump fluid end **22** of a pump **10** can avoid damage from cutting out a packing screw **92** and can provide for a reduction in pump fluid end **22** maintenance time by at least 10, 20, 30, 40, or 50% relative to removing a packing screw **92** from a pump fluid end **22** without utilizing a packing screw removal tool **100**. A reduction in pump fluid end **22** maintenance and/or assembly time reduces exposure of workers performing the maintenance (and thus potentially enhances safety) and also reduces non-productive time on location.

ADDITIONAL DISCLOSURE

The following are non-limiting, specific embodiments in accordance with the present disclosure.

A first embodiment, which is a packing screw removal tool, comprising a tool body; a plurality of packing screw engagement dogs coupled to the tool body, wherein the engagement dogs are asymmetrically disposed about an axis of rotation of the packing screw removal tool, and a torque transfer engagement post coupled to the tool body.

A second embodiment, which is the packing screw removal tool of the first embodiment, wherein the torque transfer engagement post defines a first engagement feature dimensioned to be engaged by a first wrench size.

A third embodiment, which is the packing screw removal tool of the second embodiment, wherein the first engagement feature is a triangular column, a square column, a pentagonal column, a hexagonal column, or an octagonal column.

A fourth embodiment, which is the packing screw removal tool of the second embodiment, wherein the torque transfer engagement post further defines a second engagement feature dimensioned to be engaged by a second wrench size, where the second wrench size is smaller than the first wrench size.

A fifth embodiment, which is the packing screw removal tool of the fourth embodiment, wherein the second wrench size is recessed into the first engagement feature.

A sixth embodiment, which is the packing screw removal tool of one of the first, the second, the third, or the fourth embodiment, wherein the packing screw removal tool comprises four packing screw engagement dogs.

A seventh embodiment, which is the packing screw removal tool of the first embodiment, wherein the tool body has a plate shape, a first packing screw engagement dog and a second packing screw engagement dog are located within 60 degrees on a minor axis of the tool body on a short side of the packing screw removal tool **100**.

An eighth embodiment, which is the packing screw removal tool of the seventh embodiment, wherein a third packing screw engagement dog and a fourth packing screw engagement dog are located within 60 degrees on a minor axis of the tool body on the opposite short side of the packing screw removal tool **100**.

A ninth embodiment, which is the packing screw removal tool of the seventh embodiment, wherein three packing screw engagement dogs are located within 60 degrees on the opposite short side of the tool body of the packing screw removal tool **100**.

A tenth embodiment, which is a method of removing a packing screw of a reciprocating pump, comprising bringing a packing screw removal tool to the location of a reciprocating pump, coupling the packing screw removal tool to an outside circumference of a packing screw installed in the reciprocating pump, engaging the packing screw removal tool with a wrench, applying torque by the wrench to the packing screw removal tool, turning the packing screw, after turning the packing screw, decoupling the packing screw removal tool from the outside circumference of the packing screw, after decoupling the packing screw removal tool, rotating the packing screw removal tool about an axis of the packing screw, and after rotating the packing screw removal tool, re-coupling the packing screw removal tool to the outside circumference of the packing screw.

An eleventh embodiment, which is the method of the tenth embodiment, wherein the wrench is a powered wrench.

A twelfth embodiment, which is the method of the tenth embodiment, wherein the packing screw removal tool comprises a tool body, a plurality of packing screw engagement dogs coupled to the tool body, wherein the engagement dogs are asymmetrically disposed about an axis of rotation of the packing screw removal tool, and a torque transfer engagement post coupled to the tool body.

A thirteenth embodiment, which is the method of the twelfth embodiment, wherein engaging the packing screw removal tool with the wrench comprises engaging a working feature of the wrench with a first engagement feature of the torque transfer engagement post.

A fourteenth embodiment, which is the method of the thirteenth embodiment, further comprising engaging the packing screw removal tool with a second wrench by engaging a working feature of the second wrench with a second engagement feature of the torque transfer engagement post, and applying torque by the second wrench to the packing screw removal tool.

A fifteenth embodiment, which is a packing screw removal tool, comprising a tool body having a plate shape that is longer in a first axis of a surface of the tool body than in a second axis of the surface, where the second axis is perpendicular to the first axis, a plurality of packing screw engagement dogs coupled to the tool body, wherein the engagement dogs are distributed about an axis of rotation of the packing screw removal tool and wherein the engagement dogs retain attaching hardware operable to engage in circumferential holes in an outside diameter of a packing screw, and a torque transfer engagement post coupled to the tool body, wherein the post defines a first engagement feature dimensioned to be engaged by a first wrench size and defines a second engagement feature dimensioned to be engaged by a second wrench size.

A sixteenth embodiment, which is the packing screw removal tool of the fifteenth embodiment, wherein the second engagement feature is recessed into the first engagement feature.

A seventeenth embodiment, which is the packing screw removal tool of the fifteenth embodiment, wherein the engagement dogs are aligned with the packing screw to be releasably coupled to the packing screw.

An eighteenth embodiment, which is the packing screw removal tool of the fifteenth embodiment, wherein first engagement feature is a triangular column, a square column, a pentagonal column, a hexagonal column, or an octagonal column.

A nineteenth embodiment, which is the packing screw removal tool of the fifteenth embodiment, wherein the tool body shape allows partial rotation of the packing screw.

A twentieth embodiment, which is the packing screw removal tool of the fifteenth embodiment, wherein a first packing screw engagement dog is located about 60 degrees counterclockwise from a minor axis of the tool body, a second packing screw engagement dog is located about 120 degrees counterclockwise from the minor axis of the tool body, a third packing screw engagement dog is located about 240 degrees counterclockwise from the minor axis of the tool body, and the third packing screw engagement dog is located about 300 degrees counterclockwise from the minor axis of the tool body.

While embodiments have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of this disclosure. The embodiments described herein are exemplary only and are not intended to be limiting. Many variations and modifications of the embodiments disclosed herein are possible and are within the scope of this disclosure. Where numerical ranges or limitations are expressly stated, such express ranges or limitations should be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations (e.g., from about 1 to about 10 includes, 2, 3, 4, etc.; greater than 0.10 includes 0.11, 0.12, 0.13, etc.). For example, whenever a numerical range with a lower limit, Rl, and an upper limit, Ru, is disclosed, any number falling within the range is specifically disclosed. In particular, the following numbers within the range are specifically disclosed: R=Rl+k*(Ru−Rl), wherein k is a variable ranging from 1 percent to 100 percent with a 1 percent increment, i.e., k is 1 percent, 2 percent, 3 percent, 4 percent, 5 percent, . . . 50 percent, 51 percent, 52 percent, . . . , 95 percent, 96 percent, 97 percent, 98 percent, 99 percent, or 100 percent. Moreover, any numerical range defined by two R numbers as defined in the above is also specifically disclosed. Use of the term "optionally" with respect to any element of a claim is intended to mean that the subject element is required, or alternatively, is not required. Both alternatives are intended to be within the scope of the claim. Use of broader terms such as comprises, includes, having, etc. should be understood to provide support for narrower terms such as consisting of, consisting essentially of, comprised substantially of, etc.

Accordingly, the scope of protection is not limited by the description set out above but is only limited by the claims which follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated into the specification as an embodiment of the present disclosure. Thus, the claims are a further description and are an addition to the embodiments of the present disclosure. The discussion of a reference herein is not an admission that it is prior art, especially any reference that may have a publication date after the priority date of this application. The disclosures of all patents, patent applications, and publications cited herein are hereby incorporated by reference, to the extent that they provide exemplary, procedural, or other details supplementary to those set forth herein.

What is claimed is:

1. A system for removing a packing screw, comprising:

a wellbore pumping unit comprising at least one packing screw having an axis of rotation,

wherein the at least one packing screw is generally a cylindrical shape having an outer end with a plurality of circumferential holes along an outside diameter;

a packing screw removal tool comprising:

a tool body with a plate shape;

a plurality of packing screw engagement dogs coupled to the tool body, wherein the engagement dogs are oriented parallel to an axis of rotation of the at least one packing screw and configured for an allowance fit over an outer end of the packing screw, and wherein the engagement dogs are asymmetrically disposed about the axis of rotation;

a plurality of locking pins releasably coupled to the packing screw engagement dogs, wherein the locking pins are oriented in a radial direction relative to the axis of rotation, and wherein the locking pins are configured to extend or retract in the radial direction to engage or disengage the circumferential holes of the at least one packing screw; and

a torque transfer engagement post coupled to the tool body, wherein the torque transfer engagement post extends from the tool body, and wherein the torque transfer engagement post defines a first engagement feature dimensioned to be engaged by a first wrench size.

2. The system of claim **1**, wherein the at least one of the packing screw of the wellbore pumping unit comprises a first packing screw adjacent to a second packing screw and wherein the packing screw removal tool is configured to rotate the first packing screw about the axis of rotation of the packing screw prior to removal of the second packing screw.

3. The system of claim **2**, wherein the at least one of the packing screw of the wellbore pumping unit further comprises a third packing screw, wherein the second packing screw is positioned between the first and third packing screws, and wherein the packing screw removal tool is configured to rotate the second packing screw prior to removal of the first or third packing screws.

4. The system of claim **1**, wherein the wellbore pumping unit is a high pressure oilfield pump comprising at least one plunger or piston.

5. The system of claim **4**, wherein the high pressure oilfield pump includes the at least one packing screw and primary packing for the at least one plunger, and wherein the at least one packing screw is configured to retain the primary packing in place.

6. The system of claim **5**, wherein the wellbore pumping unit includes a pump power end and a pump fluid end, wherein the pump power end is a fixed distance from the pump fluid end, wherein the at least one packing screw is coupled to the pump fluid end, and wherein the packing screw removal tool is configured to fit between the pump power end and the pump fluid end to releasably couple to one of the at least one packing screw.

7. The system of claim **1**, wherein the body comprises a short side and a long side, and wherein at least two packing

screw engagement dogs of the plurality of packing screw engagement dogs are located on the short side of the body of the packing screw removal tool.

8. The system of claim **7**, wherein the at least two packing screw engagement dogs are configured to align with the circumferential holes along an outside diameter of the at least one packing screw.

9. The system of claim **8**, wherein the plurality of packing screw engagement dogs further comprise at least three packing screw engagement dogs located on an opposite short side of the packing screw removal tool and configured to align with the circumferential holes along the outside diameter of the packing screw.

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